

Material Safety Data Sheet

Lethal Nerve Agent (VX)

Revised: 21 December 2004

Section I - General Information

Manufacturer's Address:

U.S. Army Edgewood Chemical Biological Center (ECBC)

ATTN: AMSRD-ECB-CB-CR

Aberdeen Proving Ground, MD 21010-5424

Business Phone: 410-436-4411 or 4414, Monday through Friday during the hours of 8:00 AM to 4:30 PM EDT

CAS Registry Numbers:

50782-69-9, 51848-47-6, 53800-40-1, 70938-84-0

Chemical Name:

O-ethyl S- [2-(diisopropylamino) ethyl] methylphosphonothiolate

Trade Name And Synonyms:

Phosphonothioic acid, methyl-, S- (2-bis (1-methylethylamino) ethyl) 0-ethyl ester

O-ethyl S- (2-diisopropylaminoethyl) methylphosphonothiolate

S-2-Diisopropylaminoethyl O-ethyl methylphosphonothioate

S-2 ((2-Diisopropylamino) ethyl) O-ethyl methylphosphonothiolate

O-ethyl S- (2-diisopropylaminoethyl) methylphosphonothioate

O-ethyl S- (2-diisopropylaminoethyl) methylthiolphosphonoate

S- (2-diisopropylaminoethyl) o-ethyl methyl phosphonothiolate

Ethyl-S-dimethylaminoethyl methylphosphonothiolate

VX

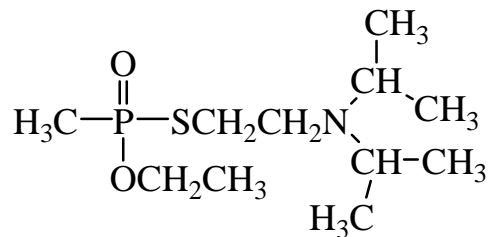
EA 1701

TX60

Chemical Family: Sulfonated organophosphorous compound

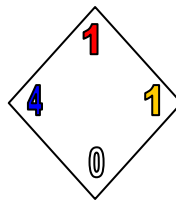
Molecular Formula and Chemical Structure:

C₁₁ H₂₆ N O₂ P S



NEPA 704 Signal:

Health - 4
Flammability - 1
Reactivity - 1
Special - 0



Section II - Ingredients

Ingredients/Name: VX

Percentage by Weight: 100%

Section III - Physical Data

Boiling Point: 292 °C (557.6 °F)

Vapor Pressure (torr): 0.000878 @ 25 °C; 0.0000422 @ 0 °C

Vapor Density (relative to air): 9.2

Solubility: Water solubility of VX is 5 % @ 21.5°C and miscible with water @ 9.4°C. Soluble in common organic solvents.

Specific Gravity (H₂O=1g/mL): 1.0113 @ 25 °C

Freezing/Melting Point (°C): Below -51 °C

Liquid Density (g/mL): 1.0083 @ 25 °C

Volatility (mg/m³): 12.6 @ 25 °C; 0.662 @ 0 °C

Viscosity (CENTISTOKES): 9.958 @ 25 °C

Molecular Weight: 267.37

Appearance and Odor: Colorless liquid when pure. Odorless when pure.

Section IV - Fire and Explosion Data

Flashpoint: 127 °C (continuously closed cup method)

Flammability Limits (% By Volume): Not Available

Lower Explosive Limit: Not Applicable

Upper Explosive Limit: Not Applicable

Extinguishing Media: Water mist, fog, foam, CO₂. Avoid using extinguishing methods that will cause splashing or spreading of the VX.

Special Fire Fighting Procedures: All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving VX should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing VX, fire-fighting personnel should wear full firefighter protective clothing during chemical agent fire-fighting and fire rescue operations. Respiratory protection is required. Positive pressure, full-face piece, NIOSH-approved self-contained breathing apparatus (SCBA) will be worn where there is danger of oxygen deficiency and when directed by the fire chief or chemical accident/incident (CAI) operations officer. In cases where firefighters are responding to a chemical accident/incident for rescue/reconnaissance purposes they will wear appropriate levels of protective clothing (See Section VIII).

Do not breathe fumes. Skin contact with nerve agents must be avoided at all times. Although the fire may destroy most of the agent, care must still be taken to assure the agent or contaminated liquids do not further contaminate other areas or sewers. Contact with liquid VX or vapors can be fatal.

Unusual Fire And Explosion Hazards: None known.

Section V - Health Hazard Data

Airborne Exposure Limits (AEL) ²:

Worker Population Limit (WPL) 8-hr TWA ¹ mg/m ³	STEL 15-min TWA ¹ mg/m ³	IDLH ¹ mg/m ³	General Population Limit (GPL) 12-hr TWA ¹ mg/m ³
0.000001	0.00001	0.003	0.0000006

¹ These values can be found in the DA, Office of the Assistant Secretary, Installations and Environment memo, subject: Implementation Guidance Policy for New Airborne Exposures Limits for GB, GA, GD, GF, VX, H, HD, and HT, 18 June 2004.

² To date, the Occupational Safety and Health Administration (OSHA) have not promulgated a permissible exposure concentration for VX.

VX is not listed by the International Agency for Research on Cancer (IARC), American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA), or National Toxicology Program (NTP) as a carcinogen.

Routes of Entry: The routes of entry for nerve agents are inhalation and ingestion, as well as eye and skin contact.

Effects of Exposure: Nerve agents are readily absorbed and are hazardous through all routes of exposure. The most prominent physiological effects results from the inhibition of the ChE enzymes distributed throughout the nervous system. The result produces effects including miosis, rhinorrhea, bronchoconstriction, increased gastrointestinal motility, muscle fasciculations, weakness, flaccid paralysis, difficulty in concentrating, anxiety, insomnia, restlessness, depression of the respiratory center, convulsions and death.

Signs and Symptoms: The onset of the signs and symptoms following exposure to nerve agents may occur within seconds, minutes, or hours, depending upon concentration, dosage, and route of entry, as well as the type and physical state of the nerve agent.

Nerve agents pose primarily a vapor hazard to the unprotected worker. Early, mild signs and symptoms of vapor exposure include miosis, conjunctival injection, pain behind the eyes, dimness or blurred vision, rhinorrhea, excessive salivation and chest tightness.

Moderate signs and symptoms of vapor exposure may include mild signs and symptoms of exposure plus: increased

shortness of breath, coughing, wheezing, voluminous bronchorrhea, nausea, vomiting and diarrhea.

Severe signs and symptoms of vapor exposure may include moderate signs and symptoms of exposure plus: generalized weakness or fasciculations/twitching, loss of consciousness (within seconds), convulsions (within minutes), severe respiratory distress, flaccid paralysis and apnea.

Effects from liquid percutaneous exposures to nerve agents are slower to develop and slower to reach their peak when compared to vapor exposures of the eyes or respiratory tract. Mild signs and symptoms of liquid nerve agent skin exposure include localized sweating at the site of exposure and fine muscle fasciculations/twitching. (**NOTE:** Miosis is not an early sign of liquid skin exposure. This is only true for exposures that include contact with airborne vapor with the eyes. In cases of nerve agent exposure not involving vapor contact with the eyes, miosis may be one of the last effects to occur. In such cases, the dosages of liquid exposure which produces miosis are not significantly different than lethal doses.)

Moderate signs and symptoms include nausea, vomiting, diarrhea, headache, and feeling of general weakness.

Severe signs and symptoms include generalized fasciculations and twitching, respiratory secretions, unconsciousness, convulsions, flaccid muscle paralysis, apnea and respiratory failure.

Toxicity Values:

Vapor (Inhalation/Ocular)¹

ECt50 (Mild) = 0.1 mg-min/m³

ECt50 (Severe)² = 10 mg-min/m³

LCt50 = 15 mg-min/m³

Vapor (Percutaneous)^{3,4}

ECt50 (Threshold)⁵ = 10 mg-min/m³

ECt50 (Severe)² = 25 mg-min/m³

LCt50 = 150 mg-min/m³

Liquid (Percutaneous)

ED50 = 2 mg/70 kg man

LD50 = 5 mg/70 kg man

¹ Estimates for inhalation vapor exposure are based on a minute volume (MV) of 15 liters. The exposure time is 2 minutes.

² Severe effects may also include death.

³ Personnel are masked.

⁴ Values for percutaneous vapor are for moderate temperatures (85 °F and below). The effective dosages for hot temperatures (85 °F and above) will be less by at least a factor of 2.

⁵ Threshold refers to a slight ChE inhibition.

Emergency and First Aid Procedures:

Prior to rendering first aid, take steps for self protection such as donning a protective mask and other protective equipment. **Immediately** remove individual from contaminated area. Decontaminate the individual as indicated below.

Vapor Exposure: Vapor exposed nerve agent casualties should be decontaminated by removing all clothing in a clean air environment and shampooing or rinsing the hair to prevent vapor off gassing.

Liquid Skin Exposure: Leave area of contamination as quickly as possible. Hold breath until respiratory protective mask is donned. Remove clothing in a clean air environment and wash the skin surface and hair in warm

or hot water at least three times. The rapid physical removal of a chemical agent is essential. Scrubbing of exposed skin with a stiff brush or bristles is discouraged, because skin damage may occur and may increase absorption of agent. Use liquid soap (dispose of container after use and replace), copious amounts of water, and mild to moderate friction with a single-use sponge or washcloth in the first and second washes. The third wash should be a rinse with copious amounts of warm or hot water. Shampoo can be used to wash the hair. If warm or hot water is not available, but cold water is, use cold water. Do not delay decontamination to obtain warm water. Two permissible alternative skin decontaminants include the M291 Skin Decontaminating Kit (SDK) and a 0.5% sodium hypochlorite solution. (**NOTE:** The use of the M291 SDK and/or 0.5% sodium hypochlorite on skin is appropriate in situations where soap and water may not be as efficacious in physically removing particular types of nerve agents, such as those used in certain research and development laboratories. Neither soap and water, 0.5% sodium hypochlorite or the M291 SDK have been shown to be more efficacious than the other for physically removing every type of nerve agent from the skin.) If used, the 0.5% sodium hypochlorite should be applied with mild to moderate friction, with a single-use sponge or washcloth in the first and second washes. The third wash should be a rinse to remove any residual sodium hypochlorite with copious amounts of warm or hot water.

Eye Contact: **Immediately** leave area of contamination and begin flushing eyes, mucous membranes, or open wounds with sterile saline or water. Flush the eyes immediately with sterile saline or water by tilting the head to the side, pulling the eyelids apart with gloved fingers and pouring slowly into the eyes. A Morgan lens may also be used for continuous eye irrigation. As soon as possible, don respiratory protective mask and leave area of contamination. Although miosis (pinpointing of the pupils) may be an early sign of agent exposure, an injection will not be administered when miosis is the only sign present. Instead, the individual will be taken **Immediately** to a medical treatment facility for observation.

Ingestion: Do not induce vomiting. First symptoms are likely to be gastrointestinal. **Immediately** administer Nerve Agent Antidote Kit, Mark I. Seek medical attention **Immediately**. **Do not handle vomited material to avoid further contamination.**

Nerve Emergency Treatment: An individual who has received a known nerve agent exposure and has progressive signs and symptoms of nerve agent exposure may receive up to three sets of the Nerve Agent Antidote Kit (Mark I). Injections may be administered at 5 to 20 minute intervals; no more than three (3) injector sets will be given unless directed by medical personnel. If severe signs of agent exposure appear [signs and symptoms of moderate exposure, plus generalized weakness or fasciculation/twitching, loss of consciousness (within seconds), convulsions (within minutes), severe respiratory distress, flaccid paralysis and apnea], immediately administer, in rapid succession, all three sets of the Mark I. In addition, a record will be maintained of all injections given.

Inhalation: If breathing is difficult, administer oxygen. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when approved mask-bag or oxygen delivery systems are not available. Do not use mouth-to-mouth resuscitation when facial contamination is present. Seek medical attention **Immediately**.

NOTE: The Office of the Surgeon General is responsible the medical guidance provided in this MSDS. Questions concerning medical guidance provided in the this MSDS may be addressed to HQDA (DASG-PPM-NC), 5109 Leesburg Pike, Falls Church, VA 22041-3258.

Section VI - Reactivity Data

Stability: Relatively stable at ambient temperature. Unstabilized VX of 95% purity decomposes at a rate of 5% a month at 71 °C. Highly purified VX is stable in both glass and steel.

Decomposition Temperature: $t_{1/2} = 502$ days @ 71 °C; $t_{1/2} = 41$ days @ 100 °C; $t_{1/2} = 34.5$ hr @ 150 °C; $t_{1/2} = 10$ hr @ 170 °C; $t_{1/2} = 1.6$ hr @ 200 °C; $t_{1/2} = 4$ min @ 250 °C; $t_{1/2} = 36$ sec @ 295 °C.

Rate of Hydrolysis: Hydrolysis rate of VX varies with temperature and concentration. At 22 °C $t_{1/2}$ = 1.8 min in 1.25M NaOH; $t_{1/2}$ = 10.8 min in 0.25M NaOH; $t_{1/2}$ = 31 min in 0.10M NaOH; $t_{1/2}$ = 3.3 hr in 0.01M NaOH; and $t_{1/2}$ = 60 hr in pure water.

Hydrolysis Products: VX hydrolyzes via three different pathways (P-S, P-O and C-S), which vary significantly with temperature and pH. At pH below 12, the P-O bond cleavage path produces ethyl methylphosphonate (EMPA) and the toxic S-[2-diisopropylaminoethyl] methylphosphonothiolate ion (EA 2192). At room temperature EA 2192 reacts slowly with OH⁻ [EA 2192, $t_{1/2}$ = 7.4 days in 1.0M NaOH], eventually producing less toxic products. Using an equimolar ratio of VX and water at elevated temperatures appears to reduce the persistency of EA 2192.

Action on Metals and Other Materials: Negligible on brass, steel and aluminum. Slight corrosion with copper.

Hazardous Polymerization: Does not occur.

Section VII - Spill, Leak, And Disposal Procedures

Steps To Be Taken In Case Material Is Released Or Spilled: If leaks or spills of VX occur, only personnel in full protective clothing will remain in the area (See Section VIII). In case of personnel contamination see Section V for emergency and first aid instructions.

Recommended Field Procedures (For Quantities Greater Than 50 Grams): Spills must be contained by covering with vermiculite, diatomaceous earth, clay or fine sand. An alcoholic HTH mixture is prepared by adding 100 milliliters of denatured ethanol to a 900-milliliter slurry of 10% HTH in water. This mixture should be made just before use since the HTH can react with the ethanol. Fourteen grams of alcoholic HTH solution are used for each gram of VX. Agitate the decontamination mixture as the VX is added. Continue the agitation for a minimum of one hour. This reaction is reasonably exothermic and evolves substantial off gassing. The evolved reaction gases should be routed through a decontaminate filled scrubber before release through filtration systems. After completion of the one-hour minimum agitation, 10% sodium hydroxide is added in a quantity equal to that necessary to assure that a pH of 12.5 is maintained for a period not less than 24 hours. Hold the material at a pH between 10 and 12 for a period not less than 90 days to ensure that a hazardous intermediate material is not formed (See Section VI). Scoop up all material and place in a DOT approved container. Cover the contents with decontaminating solution consisting of an alcoholic HTH mixture of 100 milliliters of denatured ethanol to a 900 milliliter slurry of 10% HTH in water. After sealing, decontaminate the exterior container and labeled according to EPA and DOT regulations. All leaking containers will be over packed with sorbent (e.g. vermiculite) placed between the interior and exterior containers and labeled according to EPA and DOT regulations. Dispose of decontaminate according to Federal, state, and local laws. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the STEL (See Sections V and VIII).

If the alcoholic HTH mixture is not available then the following decontaminants may be used instead and are listed in the order of preference: Super Tropical Bleach Slurry (STB) and Sodium Hypochlorite.

Recommended Laboratory Procedures (For Quantities Less Than 50 Grams): If the active chlorine of the Calcium Hypochlorite (HTH) is at least 55%, then 80 grams of a 10% slurry are required for each gram of VX. Proportionally more HTH is required if the chlorine activity of the HTH is lower than 55%. The mixture is agitated as the VX is added and the agitation is maintained for a minimum of one hour. Upon completion of the one hour agitation the decontamination mixture will be adjusted to a pH between 10 and 11. If phasing of the VX/decon solution continues after 5 minutes, an amount of denatured ethanol equal to a 10 wt.% of the total agent/decon will be added to help miscibility*. Place all material in a DOT approved container and cover the contents with additional decontaminating solution. After sealing, decontaminate the exterior of the container and label according to EPA and DOT regulations. All leaking containers will be over packed with sorbent placed between the interior and exterior containers and label according to EPA and DOT regulations. Dispose of according to Federal, State, and local laws. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the STEL

(See Sections V and VIII).

***NOTE:** Ethanol Should Be Reduced To Prevent The Formation Of A Hazardous Waste.

Waste Disposal Method: Open pit burning or burying of VX or items containing or contaminated with VX in any quantity is prohibited. Waste VX and associated decontamination solutions may be Resource Conservation and Recovery Act (RCRA) regulated hazardous wastes due to a State listing of the chemical agent, or the characteristics of the waste, to include contaminants. An evaluation of the Federal and State waste disposal regulations must be conducted to determine the appropriate disposal method.

Section VIII - Special Protection Information

Respiratory Protection:

Unprotected Workers:

<u>Concentration (mg/m³)</u>	<u>Time Limits</u>
Less than or equal to 0.000001 ¹	8 hours
Up to or less than 0.000004	2 hours ²

Protected Workers:

Type of Respiratory Protection Worn (based on monitoring results):

1. M40 Military Mask, CBRN NIOSH Approved Respirator

<u>Concentration (mg/m³)</u>	<u>Time Limits</u>
Not greater than 0.00005	Up to 8 hours ³
Greater than 0.00005 and less than 0.00007	Up to 6 hours
Greater than 0.00007 and less than 0.0001	Up to 4 hours
Greater than 0.0001 and less than 0.0002	Up to 2 hours
Not greater than 0.0005	Up to 15 minutes ⁴

2. Air Supply Line with Full Face Respirator

<u>Concentration (mg/m³)</u>	<u>Time Limits⁶</u>
0.000001 to 0.003 ⁵	Time limit will be kept at a minimum to perform the operation, and will be dictated by the local Heat Stress Program for personal protective equipment and clothing.

3. Air Supply Line with Full Face Respirator and Auxiliary Self-contained Breathing Apparatus (SCBA),

or SCBA

Concentration (mg/m³)

Greater than 0.003

Time Limits⁶

These concentrations should be expected only in emergency situations. Operations should not be conducted at these concentrations.

¹ As an 8-hr TWA average.

² Maximum continuous time at this concentration. Equivalent to 8-hr TWA. Source: Implementation Guidance Policy for Revised Airborne Exposures Limits for GB, GA, GD, GF, VX, H, HD, and HT, Dept of Army, Office of the Assistant Secretary of the Army Installations and Environment, 18 June 2004. See Table 4.

³ Canister for M40 Mask must be changed out every 6 hours of use.

⁴ Based on APF of 50 times the STEL (0.00001 mg/m³), which is a 15 minute TWA. Only one excursion to this concentration is allowed during an 8 hour workday.

⁵ The Immediately Dangerous to Life and Health Value.

⁶ For SCBA wearers, time limit is constrained by life of the air cylinder (maximum of 30 to 45 minutes). For Air Supply wearers, time limits should be kept to a minimum. Should use of the auxiliary SCBA be necessary, time limit will be constrained by the life of the breathing air cylinder, and egress from the area must be performed before its expiration.

Ventilation:

Local exhaust: Mandatory. Must be filtered or scrubbed to limit exit concentrations. Air emissions will meet local, state and federal regulations.

Special: Chemical laboratory hoods will have an average inward face velocity of 100 linear feet per minute (lfpm) +/- 20% with the velocity at any point not deviating from the average face velocity by more than 20%. Existing laboratory hoods will have an inward face velocity of 150 lfpm +/- 20%. Laboratory hoods will be located such that cross-drafts do not exceed 20% of the inward face velocity. A visual performance test using smoke-producing devices will be performed in assessing the ability of the hood to contain agent VX.

Other: Recirculation or exhaust air from chemical areas is prohibited. No connection between chemical areas and other areas through ventilation system is permitted. Emergency backup power is necessary. Hoods should be tested at least semiannually or after modification or maintenance operations. Operations should be performed 20 centimeters inside hood face.

Protective Gloves: Butyl Rubber Glove M3 and M4
Norton, Chemical Protective Glove Set

Eye Protection: At a minimum chemical goggles will be worn. For splash hazards use goggles and face shield.

Other Protective Equipment: For laboratory operations, wear lab coats, gloves and have mask readily accessible. In addition, daily clean smocks, foot covers, and head covers will be required when handling contaminated lab animals. In the case of a spill, the minimum protective clothing should be Level B after the site has been evaluated, otherwise Level A.

Monitoring: Available monitoring equipment for agent VX is the M8/M9 detector paper, detector ticket, M256/M256A1 kits, bubbler, Depot Area Air Monitoring System (DAAMS), Automated Continuous Air Monitoring System (ACAMS), Real-Time Monitor (RTM), Demilitarization Chemical Agent Concentrator (DCAC), M8/M43, M8A1/M43A1, CAM-M1, Hydrogen Flame Photometric Emission Detector (HYFED), the Miniature Chemical Agent Monitor (MINICAM), and the Real Time Analytical Platform (RTAP).

Real-time, low-level monitors (with alarm) are required for VX operations. In their absence, an Immediately Dangerous to Life and Health (IDLH) atmosphere must be presumed. Laboratory operations conducted in appropriately maintained and alarmed engineering controls require only periodic low-level monitoring.

Section IX - Special Precautions

Precautions To Be Taken In Handling and Storing: When handling agents, the buddy system will be incorporated. No smoking, eating, or drinking in areas containing agents is permitted. Containers should be periodically inspected for leaks, (either visually or using a detector kit). Stringent control over all personnel practices must be exercised. Decontaminating equipment will be conveniently located. Exits must be designed to permit rapid evacuation. Chemical showers, eyewash stations, and personal cleanliness facilities must be provided. Wash hands before meals and shower thoroughly before leaving at the end of the workday with special attention given to hair, face, neck, and hands using plenty of soap and water.

Other Precautions: Agent containers will be stored in a double containment system within a laboratory hood.

For additional information see "AR 385-61, The Army Toxic Chemical Agent Safety Program," "DA Pam 385-61, Toxic Chemical Agent Safety Standards," and "DA Pam 40-8, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, and VX"; and DA Implementation Guidance Policy for New Airborne Exposures Limits for GB, GA, GD, GF, VX, H, HD, and HT dated 18 June 2004.

Section X - Transportation Data

NOTE: Forbidden for transport other than via military (Technical Escort Unit) transport according to 49 CFR Part 173.7(b), DOD 4500.9-R and AR 50-6.

Proper Shipping Name: Toxic liquids, organic, n.o.s. (O-ethyl-S-(2-diisopropylaminoethyl) methyl phosphonothiolate)

UN ID Number: UN2810

DOT Hazard Class: 6.1, Packing Group I, Inhalation Hazard Zone A

DOT Label: Poison Inhalation Hazard or Toxic Inhalation Hazard. See 49 CFR 172.400a(a)(3) for exceptions to unit packaging labeling and 173.7(b) for other exceptions when material is transported by Technical Escort Units.

NOTE: "Poison" and "Toxic" are used interchangeably for all markings, labels and placards in continental US transportation. "Toxic" is required for international transportation.

DOT Marking: Toxic liquids, organic, n.o.s. (O-ethyl-S-(2-diisopropylaminoethyl) methyl phosphonothiolate) UN 2810, Inhalation Hazard Zone A

DOT Placard: Poison Inhalation Hazard or Toxic Inhalation Hazard

Emergency Accident Precautions And Procedures: See Sections IV, VII and VIII.

Precautions To Be Taken In Transportation: Motor vehicles will be placarded regardless of quantity. Drivers will be given full information regarding shipment and conditions in case of an emergency. AR 50-6 deals specifically with the shipment of chemical agents. Shipment of agents will be escorted in accordance with AR 740-32.

The Edgewood Chemical Biological Center (ECBC), Department of the Army believes that the data contained herein are actual and are the results of the tests conducted by ECBC experts. The data is not to be taken as a warranty or representation for which the Department of the Army or ECBC assumes legal responsibility. This information is offered solely for consideration. Any use of this data and information contained in this MSDS must be determined by the user to be in accordance with applicable Federal, State, and local laws and regulations.